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NATIONAL DAM SAFETY PROGRAM. JOHN BOLLINGER NUMBER 1 DAM (MO 31--ETC(U)
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JOHN BOLLINGER NO.1 DAM
MADISON COUNTY, MISSOURI
MO 31417

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: John Bollinger No. 1 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the John Bollinger No. 1 Dam (MO 31417).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St Louis District as a result of the application of the following criteria:

a. The combined spillway capacity will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED 14 JAN 1981
Chief, Engineering Division Date

APPROVED BY: 16 JAN 1981
Colonel, CE, District Engineer Date

A

JOHN BOLLINGER NO. 1 DAM
Madison County, Missouri
Missouri Inventory No. 31417

Phase I Inspection Report
National Dam Safety Program

Prepared by

Woodward-Clyde Consultants
Chicago, Illinois

Under Direction of
St Louis District, Corps of Engineers

for
Governor of Missouri
December 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	John Bollinger No. 1 Dam
State Located	Missouri
County Located	Madison
Stream	Unnamed Tributary of Saline Creek
Date of Inspection	16 August 1980

John Bollinger No. 1 Dam, Missouri Inventory Number 31417, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers (SLD), has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately two miles downstream of the dam. Approximately eight occupied dwellings, assorted out-buildings, and Missouri Highways 72 and Z are located in this damage zone, which extends to the outskirts of the town of Fredericktown. The contents of the damage zone were verified by aerial reconnaissance. The loss of life and property could be significant in the event of overtopping and failure of the dam.

The dam is classified as small, based on its 18 ft height and storage capacity of 62 ac-ft. The small dam classification includes dams 25 to 40 ft in height or having storage capacities of 50 to 1000 ac-ft.

Our inspection and evaluation indicate the dam is in generally good condition. No evidence of significant erosion, sliding, cracking or excessive settlement was noted on this dam. No animal burrows were noted.

Some erosion may occur in the auxiliary spillway and in the discharge channel downstream of the dam.

Seepage and stability analyses comparable to the guidelines are not on record which is considered a deficiency.

Hydraulic/hydrologic analyses indicate the 1 percent probability-of-occurrence event (100 year flood) will be passed without overtopping the dam. These analyses also indicate any storm greater than 45 percent of the PMF will overtop the embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Based on the small impounded volume of water, the small drainage basin, the broad flow area downstream of this dam, and the distance to the nearest residences, it is recommended that 50 percent of the PMF be considered as the spillway design flood.

It is recommended the following remedial measures be implemented and additional studies be made for the facilities at John Bollinger No. 1 Dam:

1. Design and construct appropriate facilities to enable the dam to pass at least 50 percent of the PMF without overtopping.

2. Evaluate options for erosion protection or relocation of downstream channel below the auxiliary spillway. Considerations should also be given to the erodible nature of the embankment and the spillway. Additional planting of grasses should be considered to provide a more uniform vegetative cover.

3. Seepage and stability analyses comparable to the requirement for the "Recommended Guidelines for Safety Inspection of Dams" should be performed.

A program of periodic inspections is recommended to:

1. Inspect seepage areas to identify increases in volume of seepage water or turbidity (soil) in the seepage water;

2. Inspect slopes for evidence of instability such as cracks or slumping;

3. Inspect discharge channel, toe of dam and auxiliary spillway for evidence of erosion.

4. Inspect the trash rack at the inlet of the main spillway to detect any conditions that might lead to spillway blockage.

Records should be kept of all inspections and any required maintenance. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of earth dams.

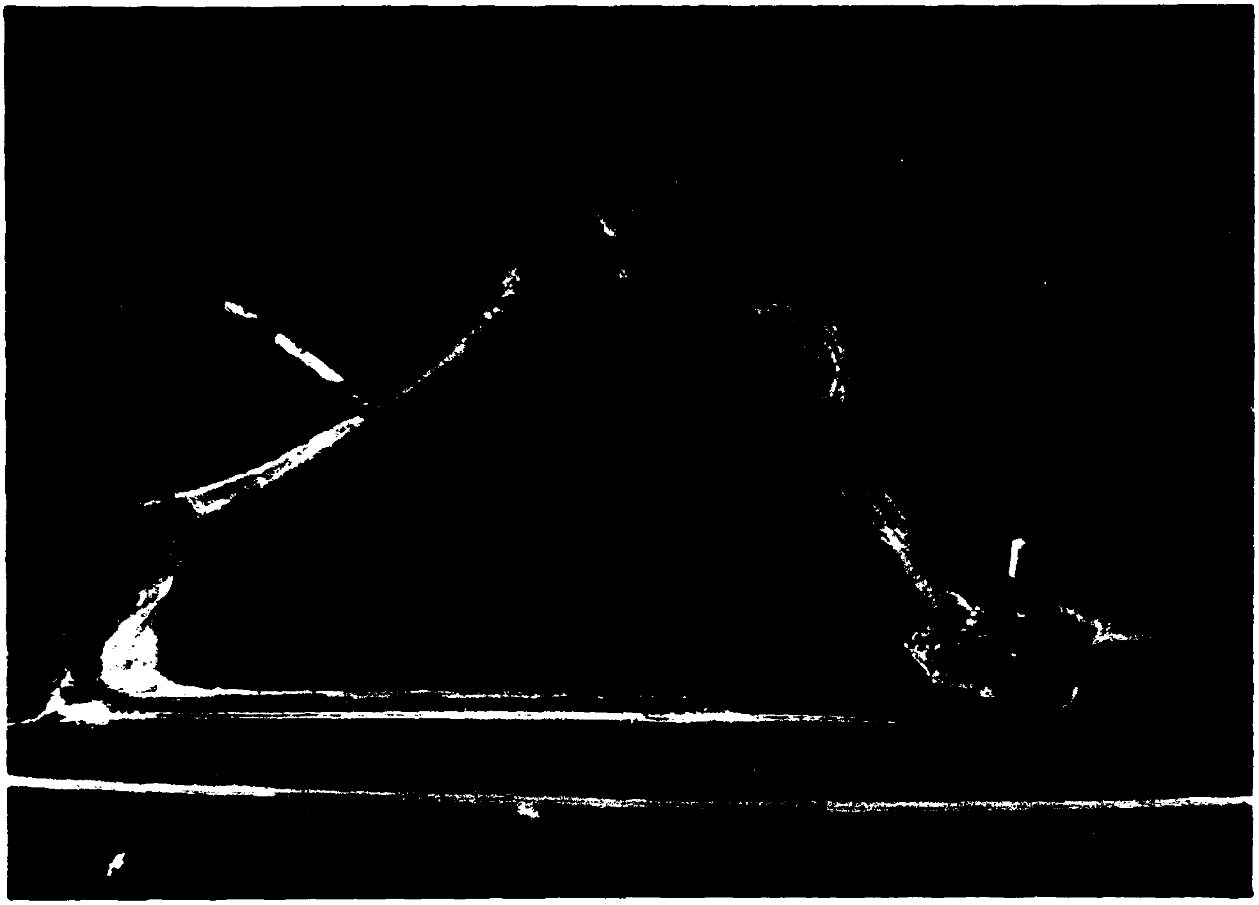
Evaluation of a practical and effective warning system is recommended to alert downstream traffic and residents should hazardous conditions develop at this dam.

The owner should take action on these recommendations without undue delay.

WOODWARD-CLYDE CONSULTANTS

Jean-Yves Perez, P.E.
Vice President

Leonard M. Krazynski, P.E.
Vice President



OVERVIEW

JOHN BOLLINGER NO. 1 DAM

MISSOURI INVENTORY NUMBER 31417

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

JOHN BOLLINGER NO. 1 DAM, MISSOURI INVENTORY NO. 31417

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
JOHN BOLLINGER NO. 1 DAM, MISSOURI INVENTORY NO. 31417

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of John Bollinger No. 1 Dam, Missouri Inventory Number 31417.

b. Purpose of Inspection. "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures, and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. Evaluation criteria. The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards Phase I Safety Inspection of Non-Federal Dams", prepared by the St Louis District, Corps of Engineers (SLD).

These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** John Bollinger No. 1 Dam is an earth dam constructed to impound a lake for irrigation. The dam was designed by the US Soil Conservation Service. The dam generally appears to be constructed in accord with the design. Design plans are presented in Appendix C.

The normal operating pool outlet or main spillway consists of a 12-in. diameter asbestos-concrete pipe through the center of the dam. The outlet of this pipe is near the toe of the maximum section. A crude trash rack has been constructed around the inlet end. No valve was noted on the pipe during the field inspection.

An auxiliary spillway is located at the right abutment (as the observer faces downstream). This auxiliary spillway consists of a broad low area subject to overtopping during flood events. The area considered as the auxiliary spillway is approximately 160 ft wide at an elevation of 794.0 ft, the minimum top of dam at the left abutment. There are no control structures for regulating flows through this auxiliary spillway.

b. **Location.** The dam is located approximately two miles northeast of Fredericktown, along Shulte Road, in Survey Number 3323, T33N, R7E, in Madison County, Missouri (Fig 1). The dam is on an unnamed tributary of Saline Creek on the USGS Fredericktown, Missouri, 7.5 minute quadrangle.

c. **Size classification.** The dam is classified as small on the basis of its storage volume of 62 ac-ft. The dam is approximately 18 ft in height. A small dam is one that impounds 50 to 1000 ac-ft or is 25 to 40 ft in height.

d. **Hazard classification.** The St Louis District, Corps of Engineers (SLD), has classified this dam as having a high hazard potential. The SLD estimated damage zone length extends approximately two miles downstream. Within this damage zone, which extends to the outskirts of the town of Fredericktown, are approximately eight occupied dwellings assorted out-buildings, and two Missouri Highways. The contents of the hazard zone were verified by aerial reconnaissance. There exists a potential for loss of life and property in the event of overtopping and failure of this dam.

e. **Ownership.** The dam is reportedly owned by Mr John Bollinger, Route 1, Fredericktown, Missouri. Correspondence should be sent to Mr Bollinger.

f. **Purpose of dam.** The dam was constructed to impound a lake to be used for irrigation of crops.

g. **Design and construction history.** The dam was constructed in 1977. Soil Conservation Service designs for the dam and outlet pipe spillway were supplied by Mr K. G. McManus of the Soil Conservation Service. Our visual inspection and survey indicate the dam was constructed in basic accordance with the design documents. These design documents are included as Appendix C.

h. **Normal operating procedures.** No operating records were found. Normal operating outflow would pass through the main spillway outlet pipe, or over the auxiliary spillway at the right abutment. The field inspection found evidence (erosion at discharge of pipe) indicating overflow through the pipe had occurred. No evidence was found of overflow at the auxiliary spillway.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.12 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A

Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation (794)	370 ft^3/sec
Total spillway capacity at maximum pool elevation (794)	370 ft^3/sec

c. **Elevation (ft above MSL).**

Top of dam	794 to 795.5
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	777.3

d. **Reservoir.**

Length of maximum pool	900 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	62

f. **Reservoir surface (acres).**

Top of dam	9
Maximum pool	9

Flood control pool	N/A
Recreation pool	N/A
Spillway crest	7.7

g. **Dam.**

Type	Compacted, earth
Length	695 ft
Height	18 ft
Top width	16 ft
Side slopes	Upstream 3(H) to 1(V) Downstream 2.2(H) to 1(V)
Zoning	None
Impervious core	None
Cutoff	2.5 ft deep trench
Grout curtain	None

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	None

i. **Spillway.**

Type	Main: 12 in. ungated, asbestos-concrete pipe through maximum section of dam. Auxiliary: uncontrolled, unlined weir at right abutment.
Length of weir	Main: N/A Auxiliary: 160 ft at elevation of top of dam (794 ft).
Crest elevation	Main: 792.2 Auxiliary: 792.4

Gates	None
Downstream channel	Main spillway: culvert under Shulte Road. Auxiliary spillway; unlined ditch at toe of dam; runs along toe of dam to junction with main spillway.

j. <u>Regulating outlets.</u> None

SECTION 2
ENGINEERING DATA

2.1 Design

Design documents for John Bollinger No. 1 Dam were supplied by Mr K. G. McManus, Soil Conservation Service State Conservationist. These documents included survey notes, design computations, drawings and survey check-out notes. Of principal use in the evaluation and visual inspections was the diagram of the cross section through the maximum section and spillway pipe. This is included in Appendix C.

The field inspection and survey of the dam identified some minor variances from the design drawings. The spillway pipe was designed as a 6-in. diameter pipe. The dam was constructed with a 12-in. diameter pipe. The auxiliary spillway was designed to be 1.5 ft higher than the inlet elevation for the spillway pipe. It was surveyed as only 0.2 ft higher.

The design drawings show an anticipated settlement of the dam fill of 1.4 ft. No records were available of the actual settlement.

Other features of the design such as placement of seepage collars and cutoff trench dimensions could not be inspected.

2.2 Construction

Field notes of an inspection visit during construction were obtained from the Soil Conservative Service. These notes describe the elevation of the dam crest at the time of the visit. However, the elevations are not referenced to Mean Sea Level Datum and could not be directly correlated to the field survey conducted for this inspection. Construction of the embankment was apparently complete but the auxiliary spillway had not been excavated. No records were available of compaction tests on the embankment materials. The embankment fill was described as class III (SCS). No other records of construction were available.

2.3 Operation

There are no operating facilities at this dam. Water levels are controlled by flow through the ungated spillway pipe and auxiliary spillway.

2.4 Evaluation

a. **Availability.** The only engineering data obtained for evaluation of this dam were from the Soil Conservation Service design drawings included in Appendix C.

b. **Adequacy.** The available data are insufficient to evaluate the adequacy of design of this dam. Stability and seepage analyses comparable to the "Recommended Guidelines for Safety Inspections of Dams" are not on record, which is considered a deficiency. These stability and seepage analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

c. **Validity.** The engineering data obtained from the Soil Conservation Service appear to generally reflect the condition of the dam, with the exception of the items mentioned in Section 2.1.

2.5 Project Geology

The dam site is located just north of the center of the Ozark structural dome. Bedrock in the area is mapped on the Geologic Map of Missouri (1979) as Cambrian age Elvins Group and Bonneterre Formation (Fig 4). The site appears to be located near the base of this section and is likely underlain by Bonneterre Formation. The Bonneterre Formation is typically a light grey, medium- to fine-grained dolomite with glauconitic or shaley partings and beds (Photo 2).

A residual clay soil profile developed on the carbonite bedrock is present over most of the site. This soil (CL-CH) is apparently the material used in the dam construction. The soil is mapped on the Missouri General Soil Map (1979) as Peridge-Cantwell-Gasconade Association.

A branch of the Simms Mountain Fault System is mapped on the Structural Features Map of Missouri approximately 2 mi northeast of the dam. The Simms Mountain System is a complex network of faults approximately 42 mi long, with displacement on the faults typically up to the southwest. The fault appears to be limited to Pre-Cambrian and lower Paleozoic formations. The southwestern end of the zone approaches the area of the large New Madrid earthquake. However, the dam site is not considered to be in a seismically active area and the fault system does not appear to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was conducted of John Bollinger No. 1 Dam on August 16, 1980, without the owner's representative present. This inspection indicated the dam was in generally good condition. The lake water surface was quite low due to a dry period prior to the inspection.

b. **Dam.** The dam is constructed of compacted earth, primarily a stiff light gray and brown silty clay (CL-CH). Some minor gravel is present. The soil appears to be a residual clay possibly developed on the carbonate bedrock in the area which is exposed near the left abutment.

The vertical and horizontal alignment of the dam appears undisrupted (Photo 3). No animal burrows were noted. The only cracks noted were shrinkage cracks in the clay formerly covered by the lake. No evidence of slumping or slope instability was noted during the inspection.

Some minor erosion rills were noted on both the upstream and downstream slopes of the dam (Photos 4, 5). The rills are perhaps 4 to 8 in. deep and locally as deep as 1 ft. They are fairly regularly spaced at about 3 ft intervals.

A series of wave cut small benches were noted on the upstream face of the dam, the highest being approximately 3 ft below the dam crest (Photo 6). There is no riprap or other erosion control on the upstream slope but the short fetch to build waves on the lake suggests none is probably needed.

Very minor seepage was noted along the toe of the dam. Cattail vegetation was growing in damp ground. The seepage was estimated at less than 1/2 gal/min.

c. **Appurtenant Structures.**

1. Main spillway. The main spillway consists of a 12-in. diameter asbestos-concrete pipe extending through the dam embankment. The inlet has a vertical riser with a crude trash rack to prevent congestion (Photo 7). The trash rack is fairly rough and the vertical beams are approximately 18 to 24 in. apart. However, the drainage basin is used exclusively for agriculture and there appears to be little chance for developing obstructions sufficient to block the pipe. No valves or controls were noted on the pipe. The outlet exits at the toe of the dam near the maximum section (Photo 8).

2. Auxiliary spillway. The auxiliary spillway is a broad low area at the right abutment. It will serve as an overflow during heavy flooding. The overflow area is ill-defined with no distinct margins. The minimum top of dam elevation considered for the overtopping analysis (Section 5) is 794.0 ft where overflow would begin over the left abutment.

The embankment materials appear moderately erodible and significant overtopping for extended periods of time could cause erosion in the auxiliary spillway.

d. **Reservoir area.** The reservoir area consists entirely of cropland. The slopes were quite flat, less than 6 or 8(H) to 1(V). Vegetation was limited to the corn crop and weeds along the lake shore. No evidence of slope instability was noted in the slopes surrounding the reservoir. Some sedimentation appears to be occurring at the upstream end of the reservoir, but no rate of siltation was measured or calculated.

e. **Downstream channel.** The channel below the main spillway pipe flows through a culvert under Shulte Road (Fig A-1, Appendix A). The channel from the auxiliary spillway flows along the toe of the dam (Photo 9). The raised roadbed of Shulte Road confines overflow runoff to the toe of the slope. During significant storms flow along toe of slope would likely erode both the toe of the dam and the roadway. High flood flows would likely overtop and erode the roadway at the culvert crossing.

3.2 Evaluation

The visual inspection indicates the dam and appurtenant structures are in generally good condition. Some erosion was noted on upstream and downstream slopes but appeared minor at the time of inspection. Additional planting of grasses should be considered to provide a more uniform vegetative cover and minimize the erosion. The downstream channel below the auxiliary spillway may cause erosion at the toe of the dam during periods of heavy rainfall unless some erosion protection is installed or the channel moved to the south side of Shulte Road.

No evidence of cracking, excessive settlement, sliding, animal burrows or disrupted horizontal or vertical alignment was noted. Seepage was very minor, less than 1/2 gal/min and was not transporting soil.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level in the reservoir is controlled by the crest of the ungated spillway pipe and auxiliary spillway.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

There are no facilities requiring operation at this dam. The trash rack at the inlet to the main spillway pipe appears to have been recently constructed and should be maintained free of debris.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There is apparently no maintenance program in effect at this facility. In view of the potential erosion along the discharge channel, and the potentially adverse effect this could have on the stability of the dam, it is recommended a maintenance program be established for this dam and appurtenant facilities. The feasibility of a practical warning system should be evaluated to alert downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** The dam was designed by the Soil Conservation Service (SCS) and some hydrologic and hydraulic design data were available. However, the pond did not comply with all the design specifications according to SCS field notes. Pertinent dimensions of the dam and reservoir were surveyed for this report on August 21, 1980, measured during the field inspection or estimated from the topographic mapping. The map used in the analysis was the USGS Fredericktown 7.5 minute quadrangle.

b. **Experience data.** No recorded history of rainfall, runoff, discharge or pool stage data were available for this reservoir or watershed.

c. **Visual observation.** The watershed is rural and cultivated. The area of the reservoir is about 13 percent of the total watershed area of 0.12 square miles.

The main spillway consists of a 12-in. diameter asbestos-concrete pipe located in the main body of the dam. The auxiliary spillway is a broad area at the right (west) abutment. Together these spillways are capable of passing approximately 425 ft^3/sec.

d. **Overtopping potential.** Hydrologic and hydraulic computations indicate that a flood greater than 45 percent PMF will overtop the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The dam will pass the 1 percent probability-of-occurrence event without overtopping the dam.

The following data are computed for various flood events assuming no erosion of the spillway or the embankment:

Percent PMF	Maximum Outflow, ft^3/sec	Maximum Lake Elevation, ft	Maximum Depth of Overtopping, ft	Duration of Overtopping, hrs
45	425	794.0	0	0
50	480	794.1	0.1	0.3
100	1050	794.7	0.7	1.1

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual inspection.** The visual inspection of John Bollinger No. 1 Dam identified no evidence of instability in the embankment. Minor erosion was noted on both the upstream and downstream slopes locally causing gullies to 1 ft deep. Measures to mitigate this erosion should be considered.

The downstream channel below the auxiliary spillway flows along the toe of the dam and could erode the toe during periods of heavy overflow runoff. The dam was built in 1977 and there is only a short history of performance. No records of overtopping were located.

b. **Design data.** Standard design drawings used for the design of John Bollinger No. 1 Dam were obtained from the Soil Conservation Service in Columbia, Missouri. The dam appears to be built generally in accordance with the available information except as noted in Section 2.1.

Seepage and stability analysis comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" are not on record. This is a deficiency which should be rectified. These analyses should be performed under appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of earth dams.

c. **Operating records.** No operating records or water level records are maintained at this facility.

d. **Post construction changes.** No post construction changes in the dam could be identified. The trash rack at the inlet appeared to be a recently constructed feature of the dam.

e. **Seismic stability.** The dam is Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction of the embankment is unlikely during a seismic event. However, since no static stability analysis is available for review, the seismic stability cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection and evaluation of the available data, John Bollinger No. 1 Dam is judged to be in generally good condition.

This judgment is based on the lack of signs of instability or significant erosion on the dam at this time. The potential for erosion at the toe, and the short history of performance indicate the need for periodic inspections to maintain the facility in good condition. Seepage and stability analyses comparable to the recommended guidelines are not on record, which is considered a deficiency.

The reservoir storage and spillways will pass 45 percent of the PMF without overtopping the dam. The spillway discharge capacity is calculated at 425 ft^3/sec.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations in this Phase I report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These analyses should be conducted under the direction of an engineer experienced in the construction of earth dams.

c. **Urgency.** The deficiencies described in this report could affect the long term safety of the dam. Corrective actions should be taken without undue delay.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which

should be performed without undue delay are described in Section 7.2b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass 50 percent of the Probable Maximum Flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but minimizes the potential for loss of life).

b. **Recommendations.** Based on our inspection of John Bollinger No. 1 Dam, it is recommended that further studies be conducted without undue delay, to evaluate as a minimum:

1. Design and construction of appropriate facilities to enable the dam to pass at least 50 percent of the PMF without overtopping.

2. Options for erosion protection or relocation of downstream channel below the auxiliary spillway. Consideration should also be given to the erodible nature of embankment and the spillway. Additional planting of grasses should be considered to provide a more uniform vegetative cover and minimize the erosion.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams".

These further studies should be conducted under the guidance of an engineer experienced in design and construction of dams.

c. <u>Operation and maintenance procedures.</u> A program of periodic inspections is recommended for the John Bollinger No. 1 Dam. This program should include, but not be limited to:

1. Inspection of seepage areas to identify increases in volume of seepage or turbidity (soil) in the seepage water.

2. Inspection of slopes to identify evidence of potential future slope instability such as cracking or slumping of the embankment.

3. Inspection of erosion rills on the face of dam to identify potential future impact on the dam stability.

4. Inspection of the trash rack at the inlet of the main spillway to detect any conditions that might lead to spillway blockage.

Records should be kept of the inspections and any required maintenance. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams.

The evaluation of a practical and effective warning system is recommended to alert downstream traffic and residents should hazardous conditions develop at this dam.

REFERENCES

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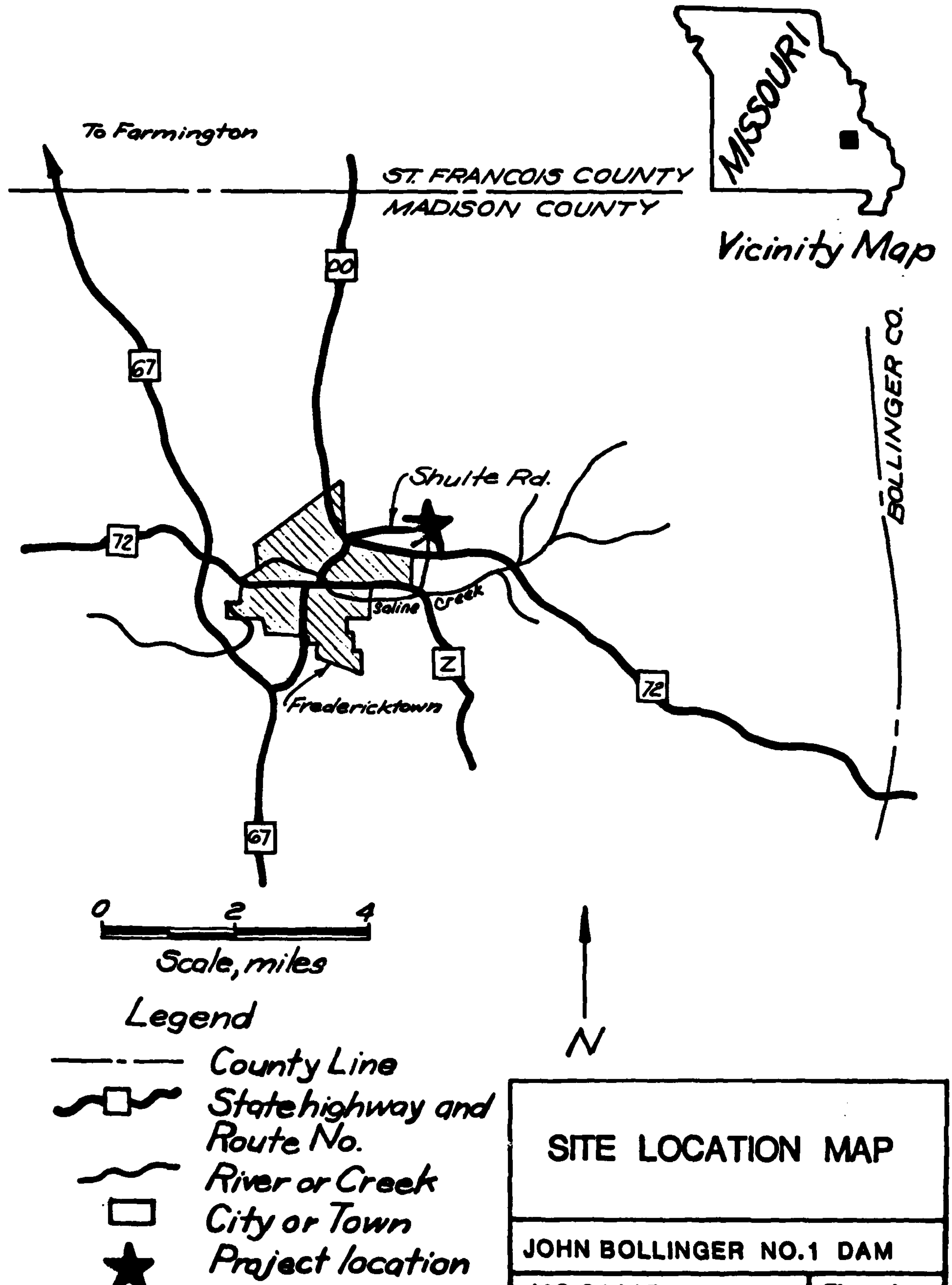
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

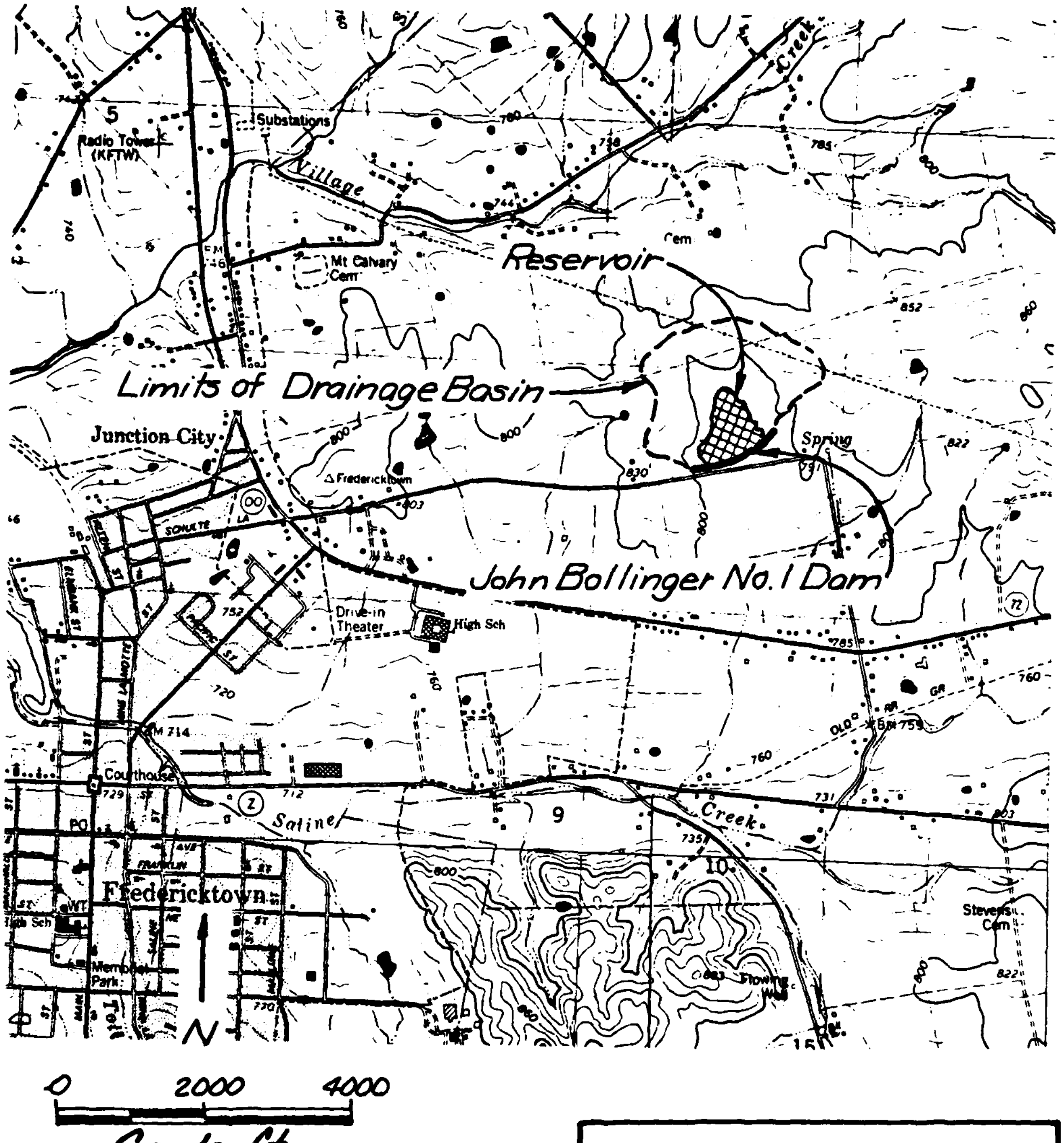
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



SITE LOCATION MAP

JOHN BOLLINGER NO.1 DAM

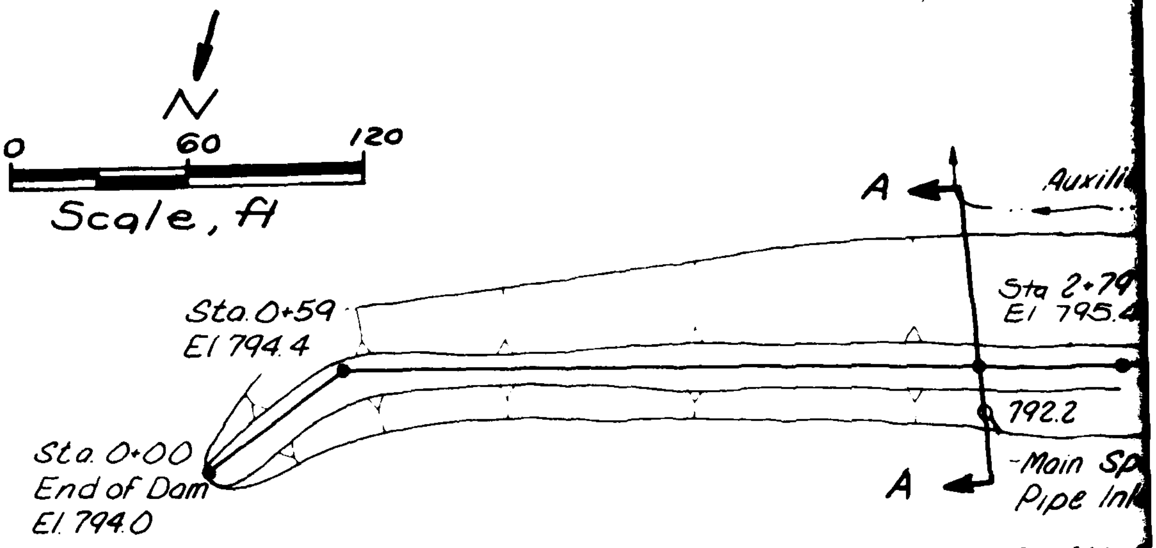
MO 31417 | Fig. 1



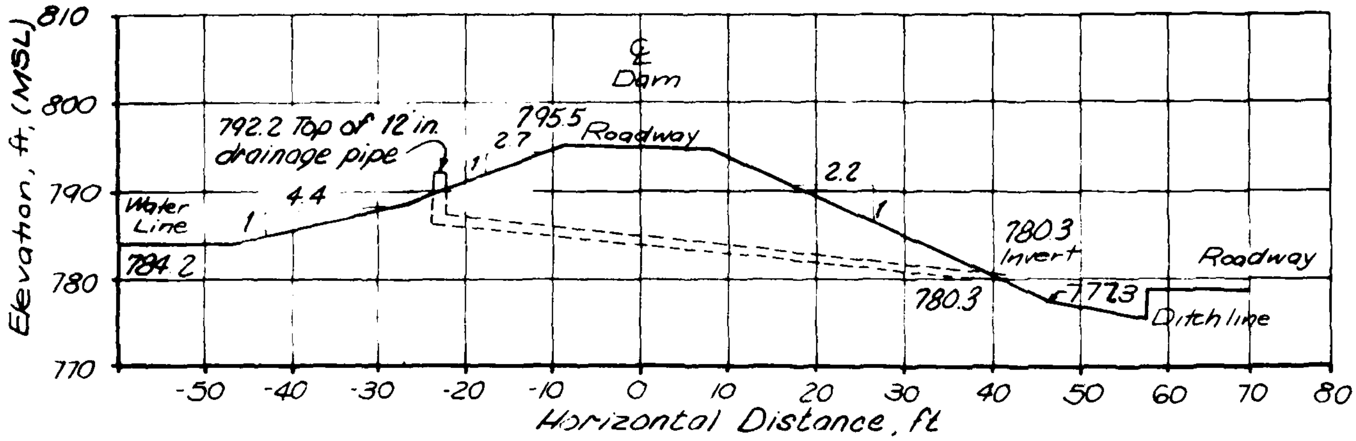
NOTE:

1. Topography from U.S.G.S. Federicktown 7.5 minute quadrangle map (1980)

DRAINAGE BASIN AND SITE TOPOGRAPHY	
JOHN BOLLINGER NO.1 DAM	
MO 31417	Fig. 2

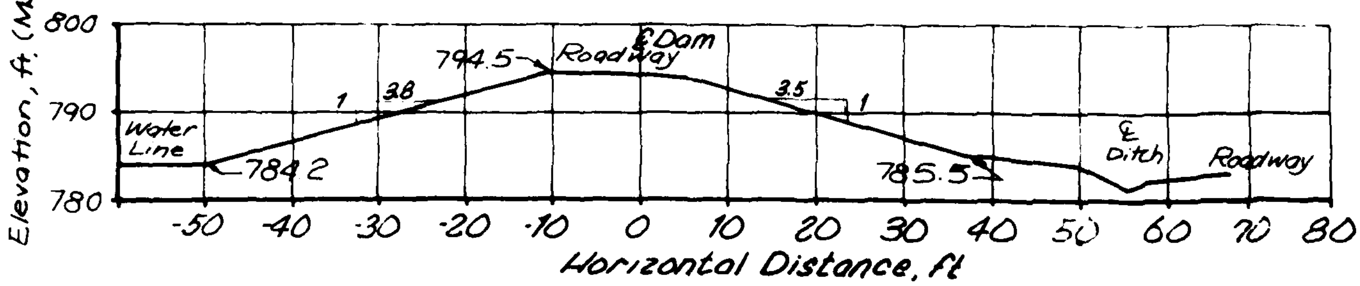


PLAN O



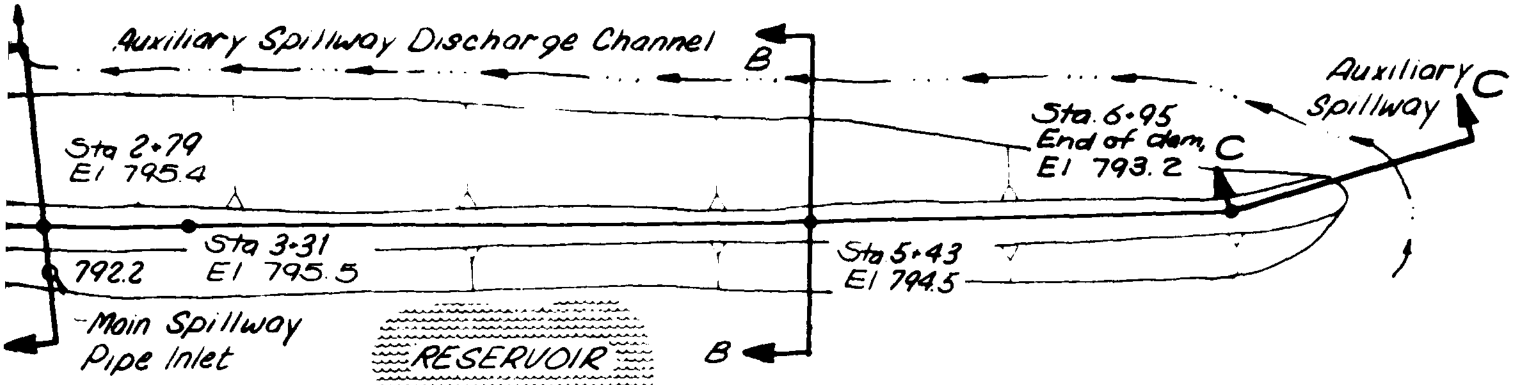
SECTION A-A

Maximum Dam Section

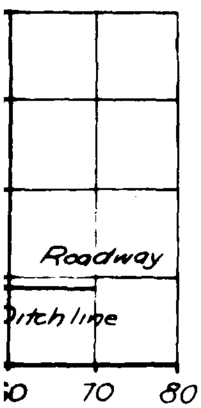


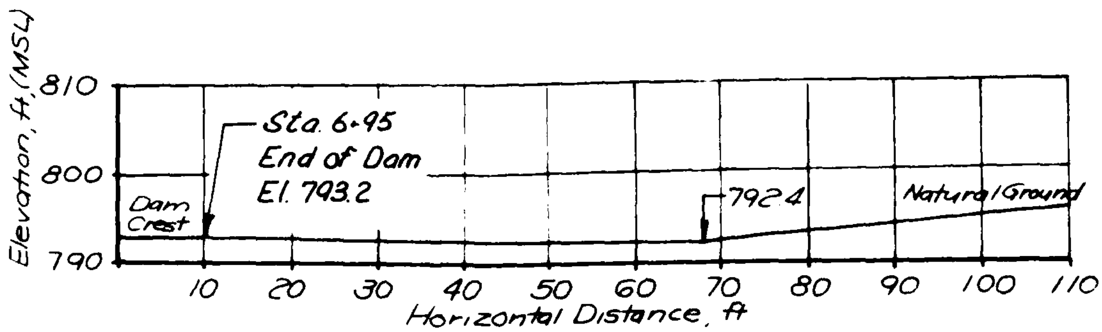
SECTION B-B

Dam Section

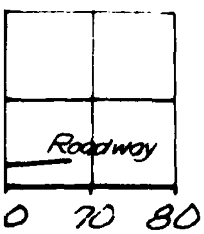


PLAN OF DAM





SECTION C-C
Auxiliary Spillway



PLAN AND SECTIONS OF DAM AND SPILLWAY	
JOHN BOLLINGER NO. 1 DAM	
MO 31417	Fig. 3

0 10 20

Scale, mile

Legend

Ojc	Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite
Or	Roubidoux Formation
	Gasconade Dolomite Gunter Sandstone Member
Cep	Eminence Dolomite Potosi Dolomite
Ceb	Derby-Doerun Dolomite Davis Formation Bonneterre Formation Whetstone Creek Member Sullivan Siltstone Member
	Reagan Sandstone Lamotte Sandstone
	Diabase (dikes and sills)
	St. Francois Mountains Intrusive Suite
	St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

JOHN BOLLINGER NO.1 DAM

MO 31417 | **Fig. 4**

APPENDIX A

Photographs

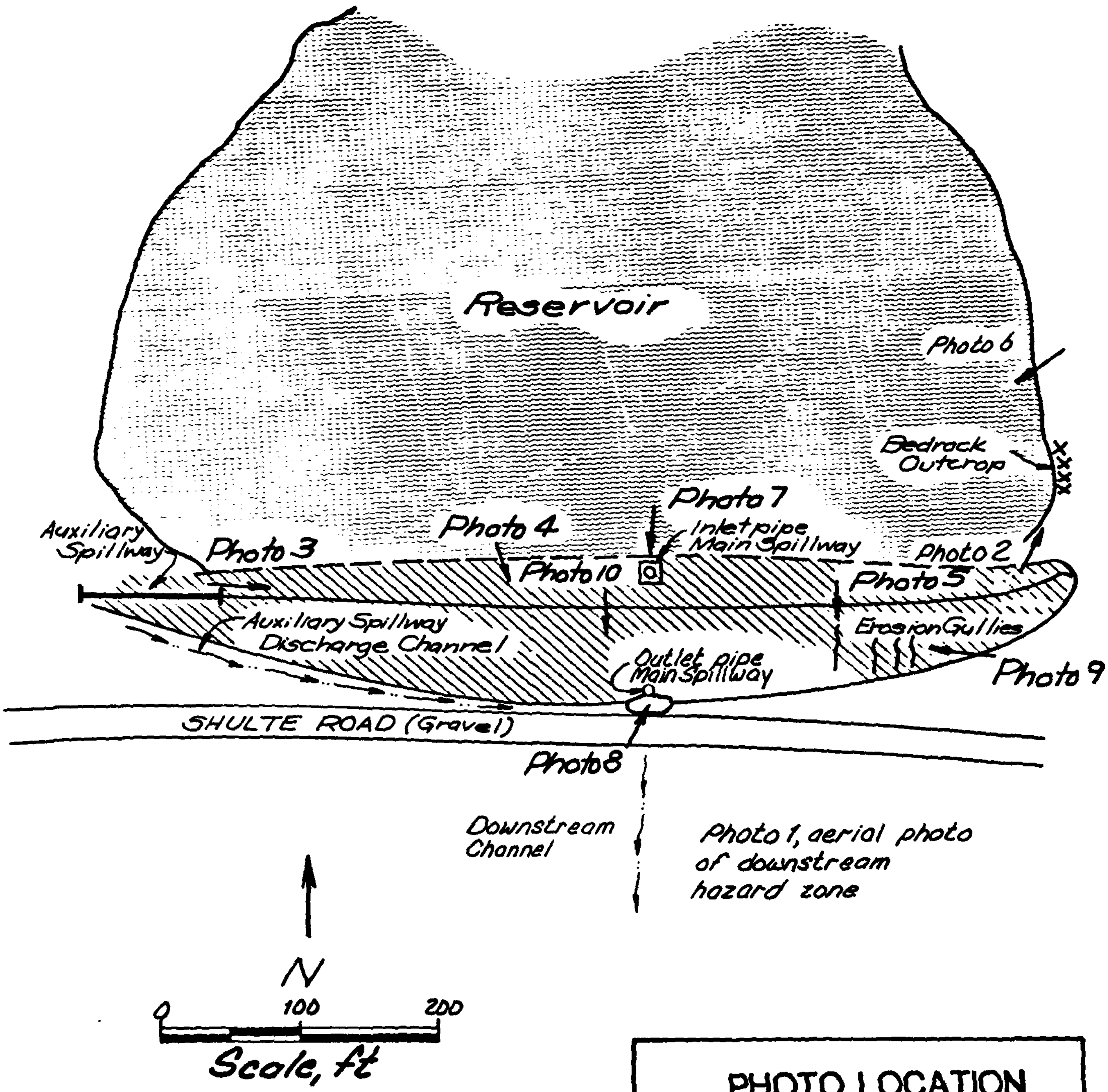


PHOTO LOCATION SKETCH	
JOHN BOLLINGER NO.1 DAM	
MO 31417	Fig. A-1

1. Downstream hazard zone below John Bollinger No. 1 Dam. Looking west; dam out of picture to the right.

2. Outcropping Bonneterre Formation (?) at left abutment. Looking north.

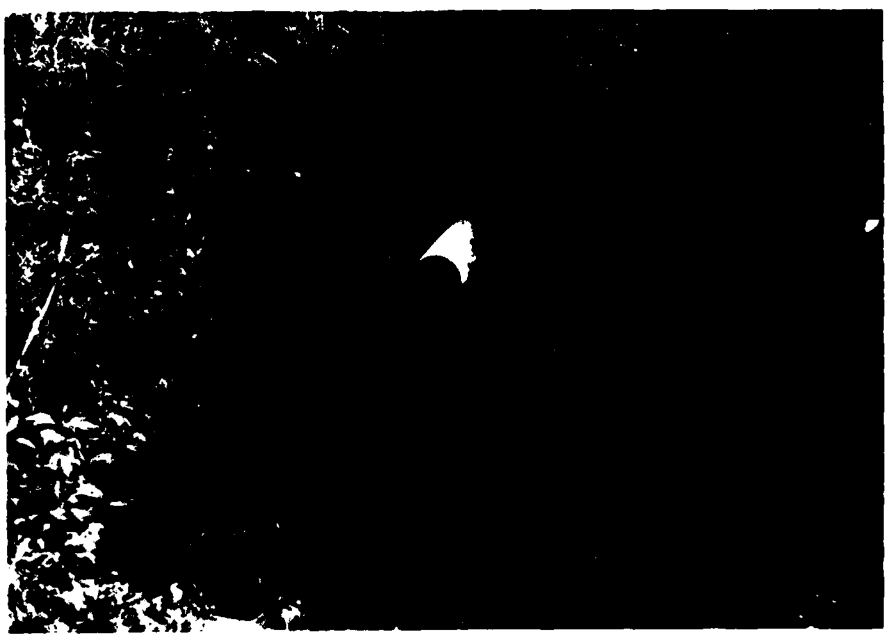
3. Roadway along crest of dam. Looking east.

4. Erosion gullies on upstream face of dam. Looking south.

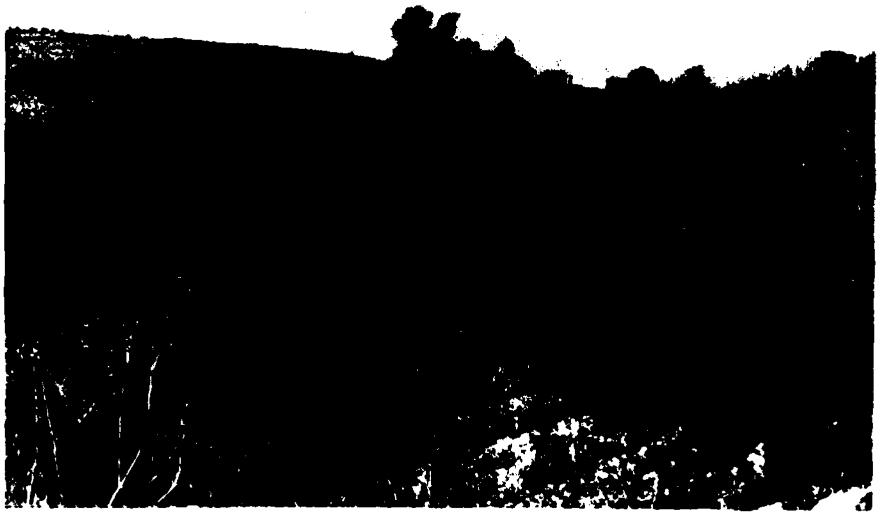
5. Erosion gully approximately 12 in. deep on downstream face of dam. Looking south.

6. Wave cut notches on upstream face of dam. Looking southwest.

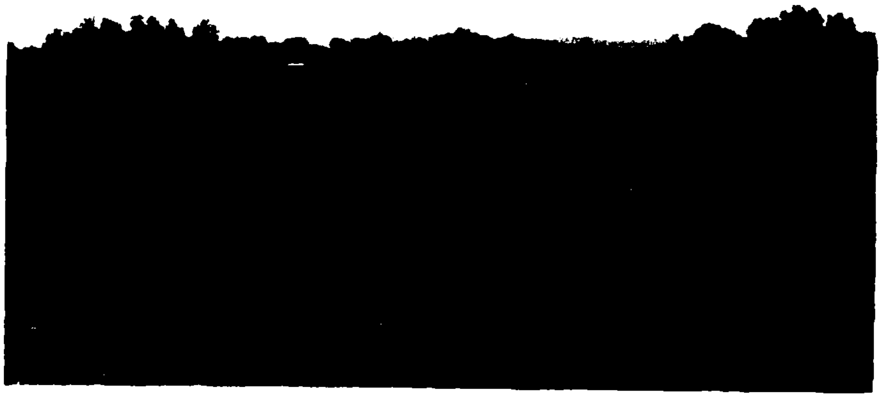
7. Inlet for main spillway pipe, with wooden beams acting as trash rack. Pipe is 12-in. diameter asbestos-concrete. Looking south.



8. Outlet for main spillway pipe at toe of maximum section. Looking north.



9. Downstream face of dam. Shulte Road visible along left center of photo. Downstream channel for auxiliary spillway runs between toe of dam and road. Looking west.



10. Downstream channel, south side of Shulte Road. Looking south from crest of dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8} (s+1)^{0.7}}{1900\ Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 5 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - high water mark, elevation 789.1 ft

(2) Probable Maximum Storm - spillway crest elevation, elevation 792.2 ft

f. Spillway Rating Curve. The HEC-2 computer program was used to compute the auxiliary spillway rating curve. The 12-in. diameter pipe main spillway capacity was calculated as 20 ft^3/sec. The two outflow capacities were combined and entered on the Y4 and Y5 computer cards for the HEC-1 program.

B.2 Pertinent Data

a. Drainage area. 0.12 m^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5-minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.32 hr

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 90
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 78

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Fredericktown 7.5 minute quadrangle map. The storage volume calculated by the Soil Conservation Service was entered on the $S and $E cards to the HEC-1 program.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The auxiliary spillway rating curve was developed from the cross-section data of the spillway. The capacity of the 12-in. diameter pipe was calculated and added to the auxiliary spillway capacity. The results of the above were entered on the Y4 and Y5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 792.2 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 789.1 ft, the elevation of the high water line in the reservoir area.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM-SAFETY VERSION      JULY 1978
 LAST MODIFICATION  01 APR 80
**********************************
    1         A1      JOHN BOLINGER NO. 1, DAM NO. 31417, MADISON COUNTY, MISSOURI
    2         A2      WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
    3         A3      PROBABLE MAXIMUM FLOW(PMF) ANALYSIS
    4         B     299       0       5      -0      -0      -0      -0      -0      -0      -0
    5         B1      5
    6         J       1       2       1
    7         J1    .50     1.0
    8         K       0    LAKE                                       1
    9         K1      JOHN BOLINGER NO. 1 INFLOW COMPUTATIONS, PMF
   10         M       1       2     .12                     1.0
   11         P       0      26     102     120     130
   12         T                                                      -1     -90             .13
   13         W2            .32
   14         X      -1    -.05       5
   15         K       1     DAM                                       1
   16         K1      FLOOD ROUTING AND OVERTOPPING ANALYSIS
   17         Y                               1       1
   18         Y1      1                                          -792.2      -1
   19         Y4  792.2   792.4   792.8   793.2   793.4   793.7   794.2   794.6   794.8   795.3
   20         Y5     0.    20.0    30.0    70.0   120.0   220.0   520.0   820.0  1020.0  1520.0
   21         $S     .2     1.7     6.2    13.7    24.1    32.4    45.1    53.2    62.1    71.6
   22         $E   781.    783.    785.    787.    789.    791.    792.    793.    794.    795.
   23         $$  792.2
   24         $D  794.0     2.8     1.5
   25         $L     0.    95.0   160.0   295.0   390.0   526.0   655.0
   26         $V  794.0   794.3   794.5   794.8   795.0   795.3   795.5
   27         K      99
```

Input Data
Various PMF Events
John Bollinger No. 1 Dam
MO   31417

B4

Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

B5

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
*********************************

RUN  DATE: 26 SEP 80
     TIME: 14.29.56

                 JOHN BOLINGER NO. 1, DAM NO. 31417, MADISON COUNTY, MISSOURI
                 WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
                 PROBABLE MAXIMUM FLOW(PMF) ANALYSIS

                                 JOB SPECIFICATION
         NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
        299        0        5       -0       -0       -0       -0       -0       -0       -0
                                 JOPER      NWT    LROPT    TRACE
                                     5       -0       -0       -0

                          MULTI-PLAN ANALYSES TO BE PERFORMED
                             NPLAN= 1 NRTIO= 2 LRTIO= 1
         RTIOS=     .50   1.00

 **********          **********          **********          **********          **********

                             SUB-AREA RUNOFF COMPUTATION

             JOHN BOLINGER NO. 1 INFLOW COMPUTATIONS, PMF

                   ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                    LAKE        0       -0       -0       -0       -0        1       -0       -0

                                   HYDROGRAPH DATA
         IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
             1        2      .12      -0.      .12     1.00      -0.       -0       -0       -0

                                     PRECIP DATA
                 SPFE      PMS       R6      R12      R24      R48      R72      R96
                   0.    26.00   102.00   120.00   130.00      -0.      -0.      -0.

                                      LOSS DATA
         LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
            -0      -0.      -0.     1.00      -0.      -0.     1.00    -1.00   -90.00      -0.      .13

          CURVE NO =  -90.00  WETNESS =   -1.00  EFFECT CN =   90.00

                                UNIT HYDROGRAPH DATA
                              TC= -0.      LAG=   .32

                                   RECESSION DATA
                    STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 5.00

        UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC=   -0.   HOURS, LAG=    .32   VOL= 1.00
      20.      65.     129.     159.     154.     127.      88.      58.      41.      28.
```

RECESSION DATA

STRTQ= -1.00 ORCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .32 VOL= 1.00

20.	65.	129.	159.	154.	127.	88.	58.	41.	28.
19.	13.	9.	6.	4.	3.	2.	1.	1.	1.
0.									

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.30	150	.22	.22	.00	159.
1.01	.10	2	.01	.00	.01	0.	1.01	12.35	151	.22	.22	.00	172.
1.01	.15	3	.01	.00	.01	0.	1.01	12.40	152	.22	.22	.00	181.
1.01	.20	4	.01	.00	.01	1.	1.01	12.45	153	.22	.22	.00	188.
1.01	.25	5	.01	.00	.01	1.	1.01	12.50	154	.22	.22	.00	192.
1.01	.30	6	.01	.00	.01	1.	1.01	12.55	155	.22	.22	.00	195.
1.01	.35	7	.01	.00	.01	1.	1.01	13.00	156	.22	.22	.00	198.
1.01	.40	8	.01	.00	.01	2.	1.01	13.05	157	.27	.26	.00	200.
1.01	.45	9	.01	.00	.01	2.	1.01	13.10	158	.27	.26	.00	204.
1.01	.50	10	.01	.00	.01	2.	1.01	13.15	159	.27	.26	.00	210.
1.01	.55	11	.01	.00	.01	2.	1.01	13.20	160	.27	.26	.00	218.
1.01	1.00	12	.01	.00	.01	2.	1.01	13.25	161	.27	.26	.00	225.
1.01	1.05	13	.01	.00	.01	2.	1.01	13.30	162	.27	.26	.00	231.
1.01	1.10	14	.01	.00	.01	2.	1.01	13.35	163	.27	.26	.00	235.
1.01	1.15	15	.01	.00	.01	2.	1.01	13.40	164	.27	.26	.00	238.
1.01	1.20	16	.01	.00	.01	2.	1.01	13.45	165	.27	.26	.00	240.
1.01	1.25	17	.01	.00	.01	2.	1.01	13.50	166	.27	.26	.00	241.
1.01	1.30	18	.01	.00	.01	2.	1.01	13.55	167	.27	.26	.00	242.
1.01	1.35	19	.01	.00	.01	2.	1.01	14.00	168	.27	.26	.00	243.
1.01	1.40	20	.01	.00	.01	2.	1.01	14.05	169	.33	.33	.00	245.
1.01	1.45	21	.01	.00	.01	2.	1.01	14.10	170	.33	.33	.00	249.
1.01	1.50	22	.01	.00	.01	2.	1.01	14.15	171	.33	.33	.00	258.
1.01	1.55	23	.01	.00	.01	3.	1.01	14.20	172	.33	.33	.00	269.
1.01	2.00	24	.01	.00	.01	3.	1.01	14.25	173	.33	.33	.00	279.
1.01	2.05	25	.01	.00	.01	3.	1.01	14.30	174	.33	.33	.00	288.
1.01	2.10	26	.01	.00	.01	3.	1.01	14.35	175	.33	.33	.00	294.
1.01	2.15	27	.01	.00	.01	3.	1.01	14.40	176	.33	.33	.00	298.
1.01	2.20	28	.01	.01	.01	4.	1.01	14.45	177	.33	.33	.00	300.
1.01	2.25	29	.01	.01	.01	4.	1.01	14.50	178	.33	.33	.00	302.
1.01	2.30	30	.01	.01	.01	4.	1.01	14.55	179	.33	.33	.00	304.
1.01	2.35	31	.01	.01	.01	4.	1.01	15.00	180	.33	.33	.00	305.
1.01	2.40	32	.01	.01	.01	5.	1.01	15.05	181	.20	.20	.00	303.
1.01	2.45	33	.01	.01	.01	5.	1.01	15.10	182	.40	.40	.00	299.
1.01	2.50	34	.01	.01	.01	5.	1.01	15.15	183	.40	.40	.00	295.
1.01	2.55	35	.01	.01	.01	5.	1.01	15.20	184	.60	.60	.00	305.
1.01	3.00	36	.01	.01	.01	5.	1.01	15.25	185	.71	.70	.00	332.
1.01	3.05	37	.01	.01	.01	5.	1.01	15.30	186	1.71	1.71	.00	400.
1.01	3.10	38	.01	.01	.01	6.	1.01	15.35	187	2.82	2.82	.01	547.
1.01	3.15	39	.01	.01	.01	6.	1.01	15.40	188	1.11	1.11	.00	771.
1.01	3.20	40	.01	.01	.01	6.	1.01	15.45	189	.71	.70	.00	1002.
1.01	3.25	41	.01	.01	.01	6.	1.01	15.50	190	.60	.60	.00	1118.
1.01	3.30	42	.01	.01	.01	6.	1.01	15.55	191	.40	.40	.00	1109.
1.01	3.35	43	.01	.01	.01	6.	1.01	16.00	192	.40	.40	.00	998.
1.01	3.40	44	.01	.01	.01	7.	1.01	16.05	193	.31	.31	.00	842.
1.01	3.45	45	.01	.01	.01	7.	1.01	16.10	194	.31	.31	.00	700.
1.01	3.50	46	.01	.01	.01	7.	1.01	16.15	195	.31	.31	.00	588.
1.01	3.55	47	.01	.01	.01	7.	1.01	16.20	196	.31	.31	.00	500.
1.01	4.00	48	.01	.01	.01	7.	1.01	16.25	197	.31	.31	.00	435.
1.01	4.05	49	.01	.01	.01	7.	1.01	16.30	198	.31	.31	.00	388.
1.01	4.10	50	.01	.01	.01	7.	1.01	16.35	199	.31	.31	.00	356.
1.01	4.15	51	.01	.01	.01	7.	1.01	16.40	200	.31	.31	.00	335.
1.01	4.20	52	.01	.01	.01	8.	1.01	16.45	201	.31	.31	.00	320.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.	1.01	16.50	202	.31	.31	.00	310.

Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

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Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

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1.01	4.00	48	.01	.01	.01	7.	1.01	16.25	197	.31	.31	.00	[illegible]
1.01	4.05	49	.01	.01	.01	7.	1.01	16.30	198	.31	.31	.00	388.
1.01	4.10	50	.01	.01	.01	7.	1.01	16.35	199	.31	.31	.00	358.
1.01	4.15	51	.01	.01	.01	7.	1.01	16.40	200	.31	.31	.00	335.
1.01	4.20	52	.01	.01	.01	8.	1.01	16.45	201	.31	.31	.00	320.
1.01	4.25	53	.01	.01	.01	8.	1.01	16.50	202	.31	.31	.00	310.
1.01	4.30	54	.01	.01	.01	8.	1.01	16.55	203	.31	.31	.00	303.
1.01	4.35	55	.01	.01	.01	8.	1.01	17.00	204	.31	.31	.00	298.
1.01	4.40	56	.01	.01	.01	8.	1.01	17.05	205	.24	.24	.00	293.
1.01	4.45	57	.01	.01	.01	8.	1.01	17.10	206	.24	.24	.00	286.
1.01	4.50	58	.01	.01	.01	8.	1.01	17.15	207	.24	.24	.00	279.
1.01	4.55	59	.01	.01	.01	8.	1.01	17.20	208	.24	.24	.00	263.
1.01	5.00	60	.01	.01	.01	8.	1.01	17.25	209	.24	.24	.00	253.
1.01	5.05	61	.01	.01	.00	8.	1.01	17.30	210	.24	.24	.00	244.
1.01	5.10	62	.01	.01	.00	8.	1.01	17.35	211	.24	.24	.00	238.
1.01	5.15	63	.01	.01	.00	9.	1.01	17.40	212	.24	.24	.00	234.
1.01	5.20	64	.01	.01	.00	9.	1.01	17.45	213	.24	.24	.00	231.
1.01	5.25	65	.01	.01	.00	9.	1.01	17.50	214	.24	.24	.00	230.
1.01	5.30	66	.01	.01	.00	9.	1.01	17.55	215	.24	.24	.00	228.
1.01	5.35	67	.01	.01	.00	9.	1.01	18.00	216	.24	.24	.00	227.
1.01	5.40	68	.01	.01	.00	9.	1.01	18.05	217	.02	.02	.00	222.
1.01	5.45	69	.01	.01	.00	9.	1.01	18.10	218	.02	.02	.00	207.
1.01	5.50	70	.01	.01	.00	9.	1.01	18.15	219	.02	.02	.00	179.
1.01	5.55	71	.01	.01	.00	9.	1.01	18.20	220	.02	.02	.00	143.
1.01	6.00	72	.01	.01	.00	9.	1.01	18.25	221	.02	.02	.00	109.
1.01	6.05	73	.07	.05	.02	10.	1.01	18.30	222	.02	.02	.00	81.
1.01	6.10	74	.07	.05	.02	13.	1.01	18.35	223	.02	.02	.00	62.
1.01	6.15	75	.07	.05	.02	17.	1.01	18.40	224	.02	.02	.00	51.
1.01	6.20	76	.07	.05	.02	23.	1.01	18.45	225	.02	.02	.00	44.
1.01	6.25	77	.07	.05	.01	29.	1.01	18.50	226	.02	.02	.00	37.
1.01	6.30	78	.07	.05	.01	35.	1.01	18.55	227	.02	.02	.00	32.
1.01	6.35	79	.07	.05	.01	39.	1.01	19.00	228	.02	.02	.00	27.
1.01	6.40	80	.07	.05	.01	41.	1.01	19.05	229	.02	.02	.00	24.
1.01	6.45	81	.07	.05	.01	44.	1.01	19.10	230	.02	.02	.00	23.
1.01	6.50	82	.07	.05	.01	45.	1.01	19.15	231	.02	.02	.00	22.
1.01	6.55	83	.07	.05	.01	47.	1.01	19.20	232	.02	.02	.00	21.
1.01	7.00	84	.07	.06	.01	48.	1.01	19.25	233	.02	.02	.00	21.
1.01	7.05	85	.07	.06	.01	49.	1.01	19.30	234	.02	.02	.00	21.
1.01	7.10	86	.07	.06	.01	49.	1.01	19.35	235	.02	.02	.00	20.
1.01	7.15	87	.07	.06	.01	50.	1.01	19.40	236	.02	.02	.00	20.
1.01	7.20	88	.07	.06	.01	51.	1.01	19.45	237	.02	.02	.00	20.
1.01	7.25	89	.07	.06	.01	51.	1.01	19.50	238	.02	.02	.00	20.
1.01	7.30	90	.07	.06	.01	52.	1.01	19.55	239	.02	.02	.00	20.
1.01	7.35	91	.07	.06	.01	52.	1.01	20.00	240	.02	.02	.00	20.
1.01	7.40	92	.07	.06	.01	53.	1.01	20.05	241	.02	.02	.00	20.
1.01	7.45	93	.07	.06	.01	53.	1.01	20.10	242	.02	.02	.00	20.
1.01	7.50	94	.07	.06	.01	53.	1.01	20.15	243	.02	.02	.00	20.
1.01	7.55	95	.07	.06	.01	54.	1.01	20.20	244	.02	.02	.00	20.
1.01	8.00	96	.07	.06	.01	54.	1.01	20.25	245	.02	.02	.00	20.
1.01	8.05	97	.07	.06	.01	54.	1.01	20.30	246	.02	.02	.00	20.
1.01	8.10	98	.07	.06	.01	54.	1.01	20.35	247	.02	.02	.00	20.
1.01	8.15	99	.07	.06	.01	55.	1.01	20.40	248	.02	.02	.00	20.
1.01	8.20	100	.07	.06	.01	55.	1.01	20.45	249	.02	.02	.00	20.
1.01	8.25	101	.07	.06	.00	55.	1.01	20.50	250	.02	.02	.00	20.
1.01	8.30	102	.07	.06	.00	55.	1.01	20.55	251	.02	.02	.00	20.
1.01	8.35	103	.07	.06	.00	55.	1.01	21.00	252	.02	.02	.00	20.
1.01	8.40	104	.07	.06	.00	56.	1.01	21.05	253	.02	.02	.00	20.
1.01	8.45	105	.07	.06	.00	56.	1.01	21.10	254	.02	.02	.00	20.
1.01	8.50	106	.07	.06	.00	56.	1.01	21.15	255	.02	.02	.00	20.
1.01	8.55	107	.07	.06	.00	56.	1.01	21.20	256	.02	.02	.00	20.
1.01	9.00	108	.07	.06	.00	56.	1.01	21.25	257	.02	.02	.00	20.
1.01	9.05	109	.07	.06	.00	56.	1.01	21.30	258	.02	.02	.00	20.
1.01	9.10	110	.07	.06	.00	56.	1.01	21.35	259	.02	.02	.00	20.
1.01	9.15	111	.07	.06	.00	57.	1.01	21.40	260	.02	.02	.00	20.
1.01	9.20	112	.07	.06	.00	57.	1.01	21.45	261	.02	.02	.00	20.

Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

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1	[illegible]	107	.07	.06	.00	56.	1.01	21.20	256	.02	.02	.00	20.
1.01	9.00	108	.07	.06	.00	56.	1.01	21.25	257	.02	.02	.00	20.
1.01	9.05	109	.07	.06	.00	56.	1.01	21.30	258	.02	.02	.00	20.
1.01	9.10	110	.07	.06	.00	56.	1.01	21.35	259	.02	.02	.00	20.
1.01	9.15	111	.07	.06	.00	57.	1.01	21.40	260	.02	.02	.00	20.
1.01	9.20	112	.07	.06	.00	57.	1.01	21.45	261	.02	.02	.00	20.
1.01	9.25	113	.07	.06	.00	57.	1.01	21.50	262	.02	.02	.00	20.
1.01	9.30	114	.07	.06	.00	57.	1.01	21.55	263	.02	.02	.00	20.
1.01	9.35	115	.07	.06	.00	57.	1.01	22.00	264	.02	.02	.00	20.
1.01	9.40	116	.07	.06	.00	57.	1.01	22.05	265	.02	.02	.00	20.
1.01	9.45	117	.07	.06	.00	57.	1.01	22.10	266	.02	.02	.00	20.
1.01	9.50	118	.07	.06	.00	57.	1.01	22.15	267	.02	.02	.00	20.
1.01	9.55	119	.07	.06	.00	57.	1.01	22.20	268	.02	.02	.00	20.
1.01	10.00	120	.07	.06	.00	57.	1.01	22.25	269	.02	.02	.00	20.
1.01	10.05	121	.07	.06	.00	58.	1.01	22.30	270	.02	.02	.00	20.
1.01	10.10	122	.07	.06	.00	58.	1.01	22.35	271	.02	.02	.00	20.
1.01	10.15	123	.07	.06	.00	58.	1.01	22.40	272	.02	.02	.00	20.
1.01	10.20	124	.07	.06	.00	58.	1.01	22.45	273	.02	.02	.00	20.
1.01	10.25	125	.07	.06	.00	58.	1.01	22.50	274	.02	.02	.00	20.
1.01	10.30	126	.07	.06	.00	58.	1.01	22.55	275	.02	.02	.00	20.
1.01	10.35	127	.07	.06	.00	58.	1.01	23.00	276	.02	.02	.00	20.
1.01	10.40	128	.07	.06	.00	58.	1.01	23.05	277	.02	.02	.00	20.
1.01	10.45	129	.07	.06	.00	58.	1.01	23.10	278	.02	.02	.00	20.
1.01	10.50	130	.07	.06	.00	58.	1.01	23.15	279	.02	.02	.00	20.
1.01	10.55	131	.07	.06	.00	58.	1.01	23.20	280	.02	.02	.00	20.
1.01	11.00	132	.07	.06	.00	58.	1.01	23.25	281	.02	.02	.00	20.
1.01	11.05	133	.07	.06	.00	58.	1.01	23.30	282	.02	.02	.00	20.
1.01	11.10	134	.07	.06	.00	58.	1.01	23.35	283	.02	.02	.00	20.
1.01	11.15	135	.07	.06	.00	58.	1.01	23.40	284	.02	.02	.00	20.
1.01	11.20	136	.07	.06	.00	58.	1.01	23.45	285	.02	.02	.00	20.
1.01	11.25	137	.07	.06	.00	58.	1.01	23.50	286	.02	.02	.00	20.
1.01	11.30	138	.07	.06	.00	58.	1.01	23.55	287	.02	.02	.00	20.
1.01	11.35	139	.07	.06	.00	59.	1.02	0.	288	.02	.02	.00	20.
1.01	11.40	140	.07	.06	.00	59.	1.02	.05	289	0.	0.	0.	20.
1.01	11.45	141	.07	.06	.00	59.	1.02	.10	290	0.	0.	0.	18.
1.01	11.50	142	.07	.06	.00	59.	1.02	.15	291	0.	0.	0.	16.
1.01	11.55	143	.07	.06	.00	59.	1.02	.20	292	0.	0.	0.	13.
1.01	12.00	144	.07	.06	.00	59.	1.02	.25	293	0.	0.	0.	11.
1.01	12.05	145	.22	.22	.01	62.	1.02	.30	294	0.	0.	0.	10.
1.01	12.10	146	.22	.22	.00	72.	1.02	.35	295	0.	0.	0.	8.
1.01	12.15	147	.22	.22	.00	92.	1.02	.40	296	0.	0.	0.	7.
1.01	12.20	148	.22	.22	.00	116.	1.02	.45	297	0.	0.	0.	6.
1.01	12.25	149	.22	.22	.00	139.	1.02	.50	298	0.	0.	0.	5.
							1.02	.55	299	0.	0.	0.	4.
									SUM	33.80	32.67	1.13	30380.
										(859.)(	830.)(	29.)(	860.27)

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	LAKE	.12 (.31)	1 (	559. 15.83)(	1118. 31.65)(
ROUTED TO	DAM	.12 (.31)	1 (	475. 13.45)(	1048. 29.68)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	792.20	792.20	794.00
STORAGE	47.	47.	62.
OUTFLOW	0.	0.	400.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	794.12	.12	63.	475.	.33	16.00	0.
1.00	794.68	.68	69.	1048.	1.08	16.00	0.

Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

Output Summary
Various PMF Events
John Bollinger No. 1 Dam
MO 31417

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .40	RATIO 2 .45	RATIO 3 .50
				RATIOS APPLIED TO FLOWS		
HYDROGRAPH AT	LAKE	.12	1	447.	503.	559.
		(.31)		(12.66)(	14.24)(	15.83)(
ROUTED TO	DAM	.12	1	373.	424.	475.
		(.31)		(10.57)(	12.02)(	13.45)(

SUMMARY OF DAM SAFETY ANALYSIS

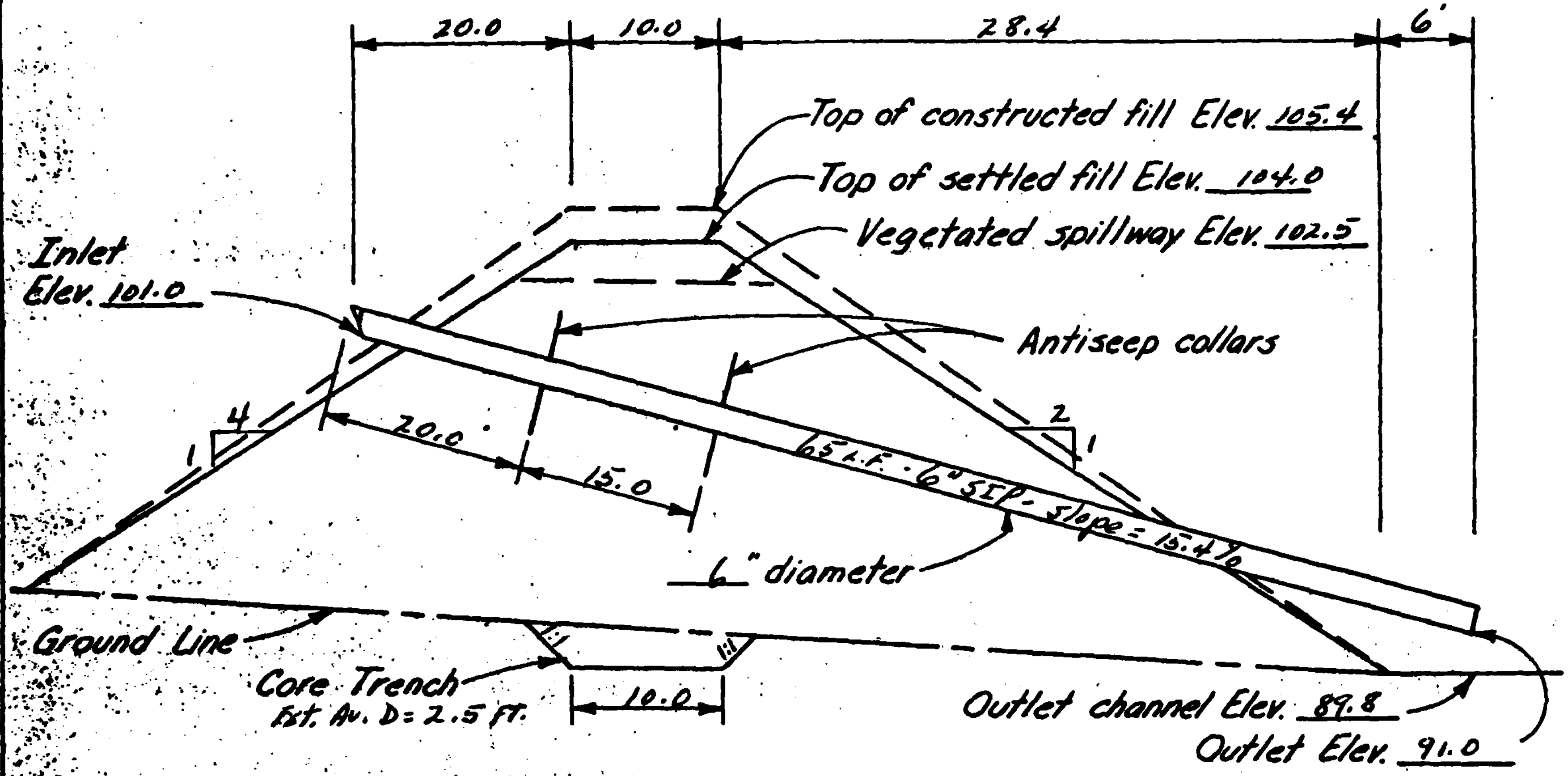
PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	792.20	792.20	794.00
STORAGE	47.	47.	62.
OUTFLOW	0.	0.	400.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	793.96	0.	62.	373.	0.	16.00	0.
.45	794.04	.04	62.	424.	.17	16.00	0.
.50	794.12	.12	63.	475.	.33	16.00	0.

APPENDIX C

Soil Conservation Service Design Data



SECTION ALONG ℄ PRINCIPAL SPILLWAY

Not to Scale

ESTIMATED QUANTITIES

QUAN.	UNIT	ITEM
10,308	Cu. Yds.	Earthfill
891	Cu. Yds.	Est. Core Trench
65	L.F.	6" SIP Conduit - 12 Gage or heavier.
2	Ea.	Anti-Seep Collars - (36" x 36"). Same Material
1	Ea.	Trash Guard - Dwg. No. 5E, 34,409

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

~~HOOD or~~ CANOPY

INLET SPILLWAY

Landowner John Bellinger

Madison County, Missouri

Designed by Ames Date 10-7-77

Checked by Date

Approved by Ames Date 10-7-77

Sheet of

MO-ENG-40
Rev. 6/73
File Code: ENG-13

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGN SHEET FOR CLASS II, III, IV * DETENTION STORAGE STRUCTURE
~~WITH DROP INLET SPILLWAY -- HOOD INLET SPILLWAY~~ -- CANOPY INLET SPILLWAY *

Landowner JOHN PELLINER County Madison

Design by [illegible] Date 10-7-77 Checked by ______ Date ______

Drainage area = 76 ac. Height x storage = 12.7 x 65 = 827

WATERSHED CONDITIONS AND FACTORS

Location factor:	L = 1.0
Infiltration factor: ~~(above)~~ (average) ~~(below)~~ *	I = 1.0
Topographic factor: 6 % average slope	T = 0.9
Shape factor: runoff distance = 2100 ft.	S = 1.1
Cover factor: cropland 100 %, pasture — %, timber — %	V = 1.0
Contouring factor:	C = 0.9
Storage factor: 75 % terraced	P = 0.9

PEAK RATE OF RUNOFF AND VOLUME OF RUNOFF

Product of factors = L x I x T x S x V x C x P = 0.8 Q_{10} = 158 c.f.s.

V x I = 1.0 x 1.0 = 1.0

For Principal Spillway Design:

10 -year peak rate of runoff = Q_{ip} = 1.0 x 158 c.f.s. = 158 c.f.s.

Rate of volume of runoff = .16 ac. ft./ac. (Table 1, 1519)

Total volume of runoff = V_{rp} = (drainage area) x (rate of volume of runoff) x L =

76 ac. x .16 ac. ft./ac. x 1.0 = 12.16 ac. ft.

For Both Spillways (Total Structure):

25 -year peak rate of runoff = Q_i = 1.3 x 158 c.f.s. = 205 c.f.s.

Rate of volume of runoff = .20 ac. ft./ac.

Total volume of runoff = V_r = 76 ac. x .20 ac. ft./ac. x 1.0 = 15.2 ac. ft.

*Mark out those items that do not apply.

Instructions for use of form: Make one pencil copy for applicable structure. File with other worksheets and structure plan in landowner's folder in field office.

Sig. Elev. 162.5

PRINCIPAL SPILLWAY DESIGN

Available storage at stage of 1.5 ft. = V_{sp} = 12.52 ac. ft. (See map)

V_{sp} + V_{rp} = 12.52 ac. ft. + 12.16 ac. ft. = 1+. Q_{op} + Q_{ip} = — (Table 2, 1519)

Q_{op} = — c.f.s. x — = — c.f.s.

Conduit:

Type S/E Length = 65 ft. Total head on conduit = 11.5 ft.

Diameter = 6 in. Discharge capacity = 1.1 c.f.s. (1520)

Minimum entrance head = .8 ft. (1510 or 1511)

Riser: **

Type ______ Height = ____ ft. Diameter = ____ in. (1511)

EMERGENCY SPILLWAY DESIGN

$\frac{12.52 \times 12}{1.1 \times .8} = \frac{150.24}{0.88} = 170$ Hrs.

Control Section:

Depth of flow = 0.5 ft. V_s at this depth = 16.95 ac. ft. (See map)

V_s + V_r = 16.95 ac. ft. + 15.2 ac. ft. = 1+

Q_{op} + Q_i = — c.f.s. + — c.f.s. = —. Q_{oe} + Q_i = — (Table 3, 1519)

Q_{oe} = — c.f.s. x — = — c.f.s.

Width = 10 ft. Total depth = depth of flow + freeboard = 0.5 ft. + 1.0 =

1.5 ft. Use 1.5 ft. (Table 4, 1517) Double spillway staked.

Exit Section:

Slope = ____ % Quality of vegetation: (fair) (good) (excellent) *

(Less) (More) * erosive soils. Permissible velocity = ____ f.p.s. (1517)

Depth = ____ ft. Design velocity = ____ f.p.s. Width = ____ ft. (1517 or 1505)

Use width of ____ ft.

ANTI-SEEP COLLARS

Length of saturated zone = L = ____ ft. Collar addition = ____ ft. (1515)

Number = n = (L x ____) + V = (____ x ____) + ____ = ____. Use 2 collars.

36" x 36"

Chart used

* Mark out those items that do not apply.
** Applies only to Drop Inlet Spillways.

S.C.-SS 170-8(8)

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